National Aeronautics and Space Administration

NASA Advisory Council
HEO Committee

William Gerstenmaier
Associate Administrator
NASA Human Exploration and Operations

Why Human Space Exploration?

- Scientific and human exploration and pioneering mark advancing civilizations and expand human experience
  - Expands knowledge, fuels innovation, and spurs commerce
  - Requires risk acceptance

- Exploration and pioneering leverages humanity's powerful motivations:
  - Ignites our imaginations
  - Leads to discovery and science & technical advances
  - Creates a vision of a better future for the next generations

- Space exploration is human and robotic explorers in partnership
  - Robots explore distant and hazardous environments to extend scientific understanding and planning for human missions
  - Human explorers provide greater speed, intuitive ease, and efficiency

- Human space exploration garners national prestige and unites nations around a common goal

Building on our investments in technology, robotic missions, International Space Station, Commercial Crew & Cargo, Space Launch System, and Orion, America is poised to lead the next wave of partnerships for international science and human space exploration

Mission Directorate Alignment for Pioneering Space

TODAY

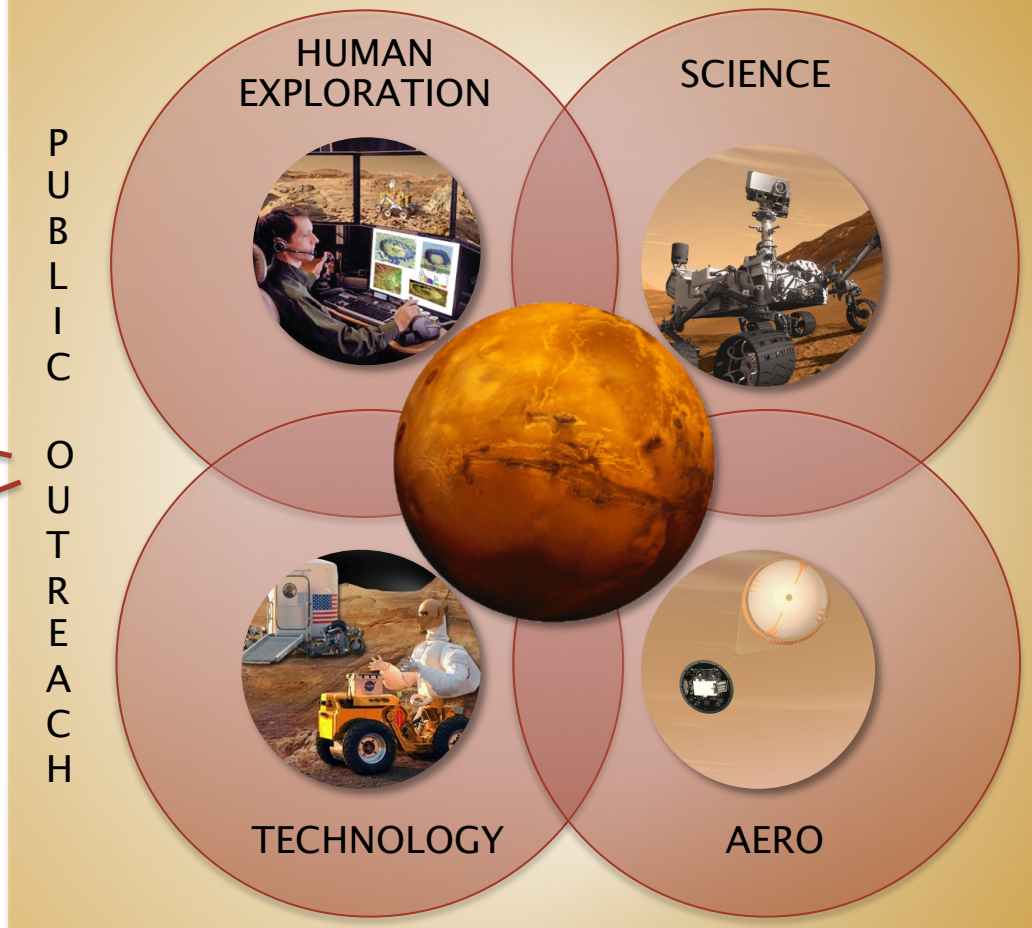
- Office of Communications
- HUMAN EXPLORATION & OPERATIONS (HEOMD)
- SCIENCE (SMD)
- EXTERNAL PARTNERSHIPS
- AERO (ARMD)
- TECHNOLOGY (OCT / Space Technology Program)
- Legislative Affairs

NASA sets the stage today for this to happen. It is a starting point for the future of Mars Exploration.

FUTURE

INTERNATIONAL PARTNERS

PUBLIC OUTREACH



COMMERCIAL PARTNERS

GOVERNMENT STAKEHOLDERS

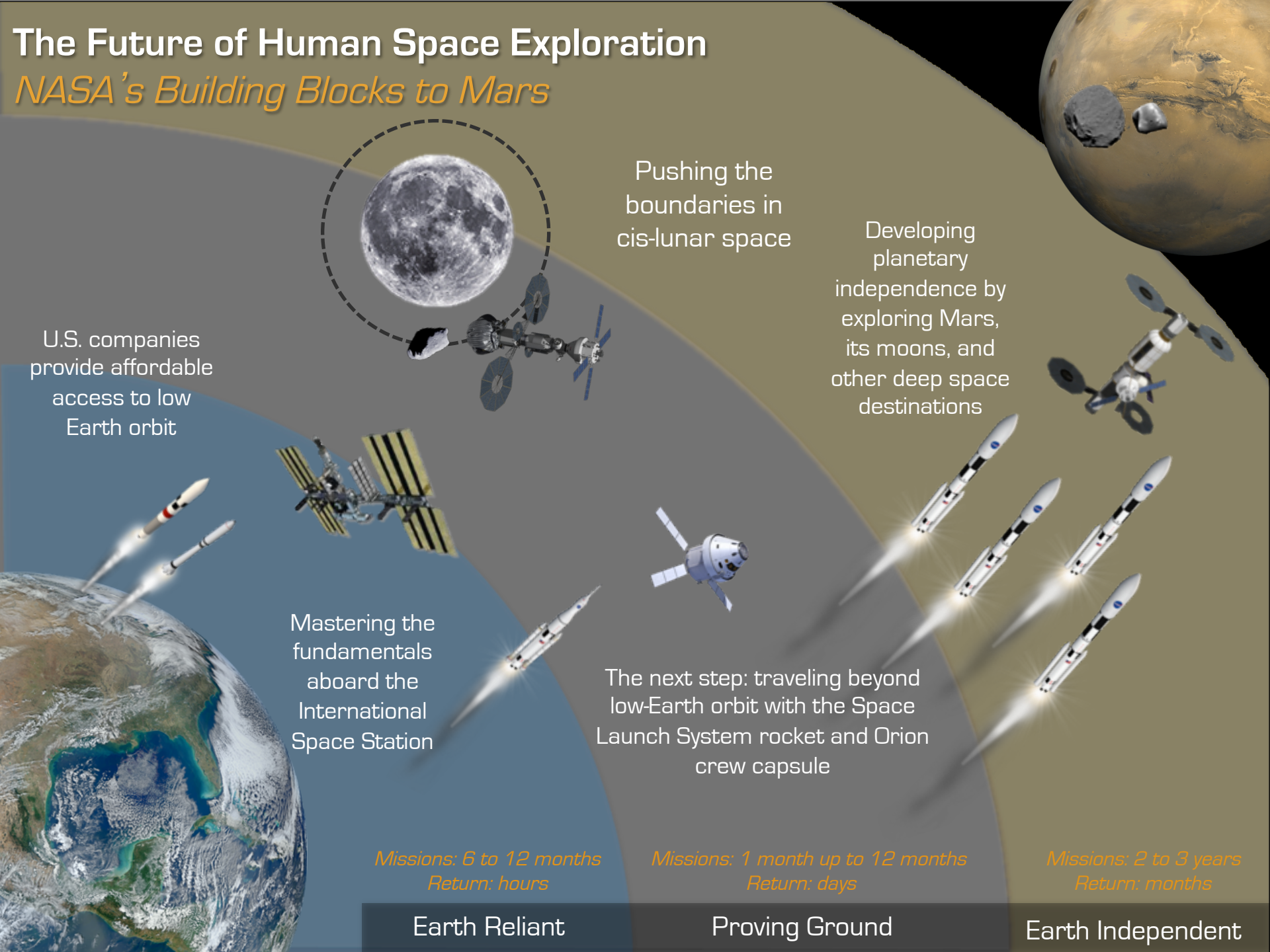
Strategic Principles for Exploration Implementation

Six key strategic principles to provide a sustainable program:

1. Implementable in the ***near-term with the buying power of current budgets*** and in the longer term with budgets commensurate with economic growth*;*
2. Application of ***high Technology Readiness Level*** (TRL) technologies for near term missions, while focusing sustained investments on ***technologies and capabilities*** to address challenges of future missions;
3. ***Near-term mission opportunities*** with a defined cadence of compelling human and robotic missions providing for an incremental buildup of capabilities for more complex missions over time;
4. Opportunities for ***U.S. commercial business*** to further enhance the experience and business base learned from the ISS logistics and crew market;
5. ***Multi-use, evolvable*** space infrastructure;
6. Substantial ***international and commercial participation***, leveraging current International Space Station partnerships.

The Future of Human Space Exploration

NASA's Building Blocks to Mars



ISS Research and Development Conference

Discoveries, Applications and Opportunities

June 17-19, 2014

Hyatt Regency McCormick Place
2233 S. Martin L. King Drive
Chicago, Illinois 60616

1954 2014
American Astronautical Society
60th Anniversary
www.astronautical.org

CASIS
www.iss-casis.org

- **3rd Annual ISS R&D Conference last week in Chicago focused on ISS discoveries, applications and opportunities in microgravity, space and Earth science, enabling technologies and STEM education**
- **Widely attended by scientists and technologists representing universities, medical centers, commercial companies, other Government Agencies, aerospace companies, NASA, science museums and the media**
- **Awards presented in the areas of Most Compelling Results from the ISS in 2013; Biotechnology, Health and Education; Engineering and Technology Development Focusing on Commercial and Exploration Applications; and Discoveries in Microgravity**
- **Special guests speakers included Nobel Laureate Professor Sam Ting (AMS), Astronaut Nicole Stott, and SMD AA John Grunsfeld**
- **Three special sessions included ISS-Pathway to Mars; Innovative Commercial Uses of the ISS; and Entrepreneurship on the ISS**
- **Parallel sessions included Biology and Biotechnology; Technology Demonstrations; Space and Earth Science; Space Communications Technologies; Human Research; STEM Education; and ISS Capabilities and Opportunities**

DISCOVERIES IN PHYSICS

FACILITY	ORIGINAL PURPOSE, EXPERT OPINION	DISCOVERY WITH PRECISION INSTRUMENT
30 GeV Proton Accelerator CERN (1960's)	Nuclear Force	Neutral Currents
30 GeV Proton Accelerator Brookhaven (1960's)	Nuclear Force	2 types of neutrinos Break down of time reversal symmetry; New form of matter
400 GeV Proton Accelerator FNAL (1970's)	Neutrino Physics	5th and 6th types of quark
Electron Positron Collider SLAC Spear (1970's)	Properties of quantum electricity	Quark inside protons 4th type of quark 3rd kind of electrons
Electron Positron Collider PETRA (1980's)	6th kind of quark	Gluon
Large Underground Cave Super Kamiokande (2000)	Proton life time	Neutrino has mass
Hubble Space Telescope (1990's)	Galactic survey	Curvature of the universe, dark energy
AMS on ISS	Dark Matter, Antimatter, Strangelets...	?

Slide courtesy of Nobel Laureate Professor Samuel Ting

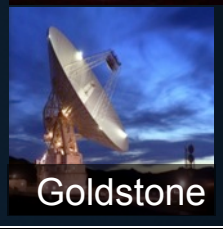
Asteroid Redirect Mission: Three Main Segments

IDENTIFY

Ground and space based assets detect and characterize potential target asteroids


Pan-STARRS


NEOWISE

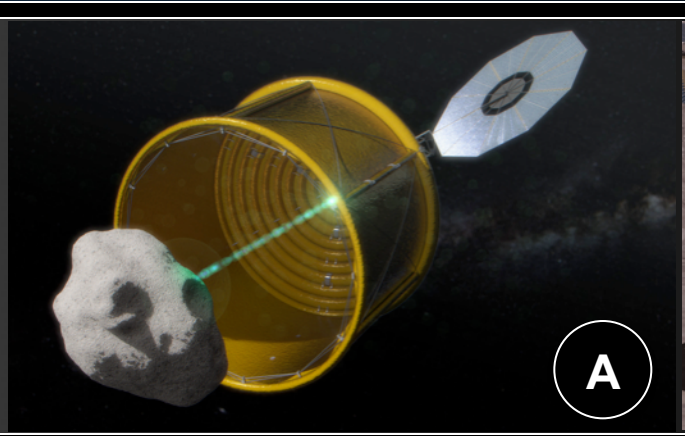

Goldstone

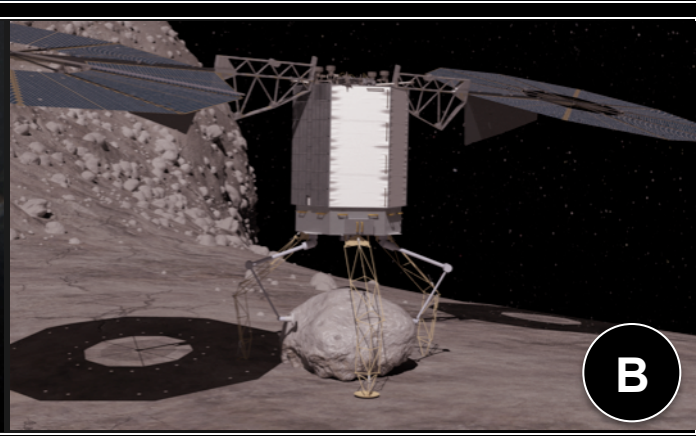

Arecibo


Infrared Telescope Facility

REDIRECT

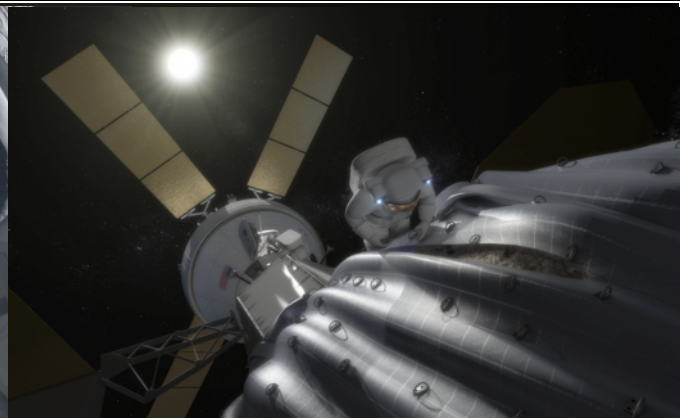
Solar electric propulsion (SEP) based system redirects asteroid to cis-lunar space (two capture options)





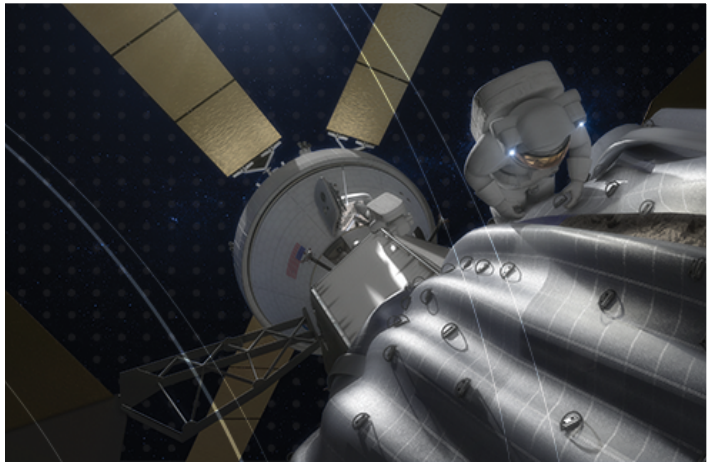
EXPLORE

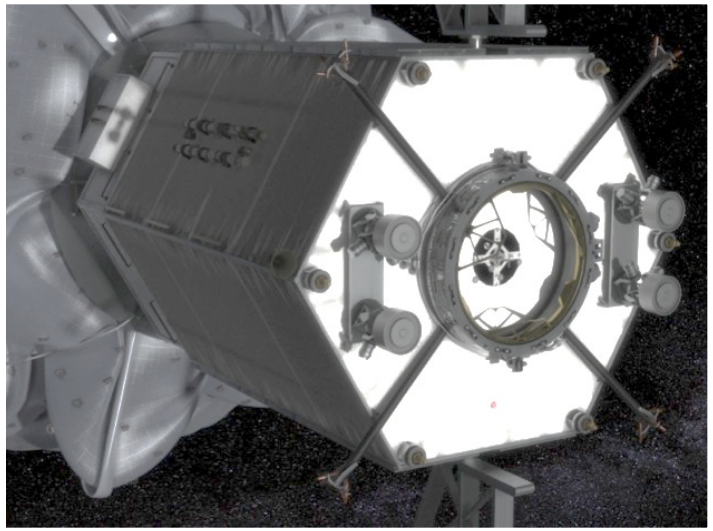
Crews launches aboard SLS rocket, travels to redirected asteroid in Orion spacecraft to rendezvous with redirected asteroid, studies and returns samples to Earth



Objectives of Asteroid Redirect Mission

- Conduct a human exploration mission to an asteroid in the mid-2020's, providing systems and operational experience required for human exploration of Mars.
- Demonstrate an advanced solar electric propulsion system, enabling future deep-space human and robotic exploration with applicability to the nation's public and private sector space needs.
- Enhance detection, tracking and characterization of Near Earth Asteroids, enabling an overall strategy to defend our home planet.
- Demonstrate basic planetary defense techniques that will inform impact threat mitigation strategies to defend our home planet.
- Pursue a target of opportunity that benefits scientific and partnership interests, expanding our knowledge of small celestial bodies and enabling the mining of asteroid resources for commercial and exploration needs.





ARM in NASA's Exploration Strategy

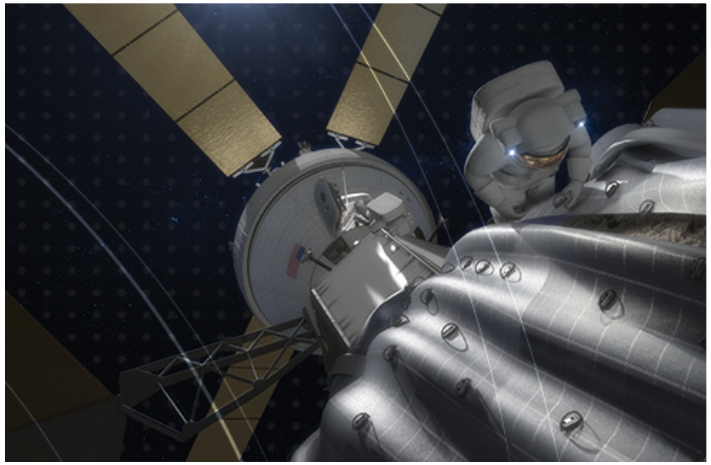
- **ARM leverages on-going activities across the Agency to implement a compelling and affordable human exploration mission in the proving ground, providing systems and operational experience for human missions to Mars**

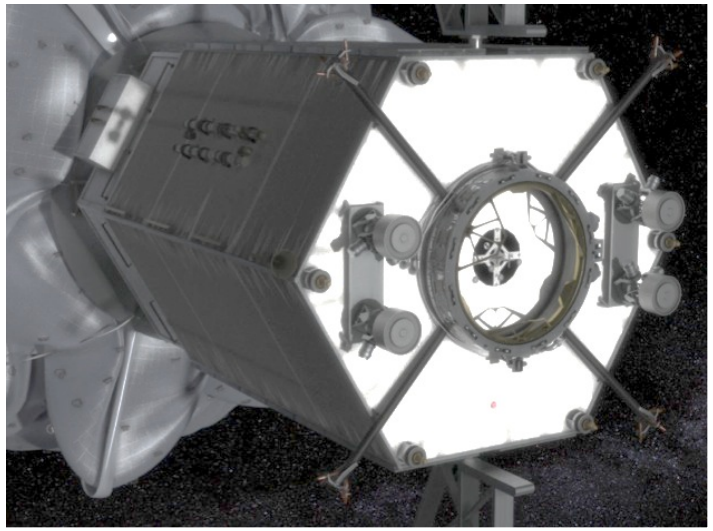
- **ARM technologies, systems, capabilities are part of our sustainable exploration strategy**
  - High power SEP systems scalable to support human missions to Mars, e.g. pre-emplacement of cargo
  - Upgradable entire SEP spacecraft bus options sought through recent Broad Agency Announcement (BAA)
  - Capture and control of non-cooperative objects
  - Common rendezvous and docking systems, international docking system, systems for beyond LEO in-space EVA
  - Opportunities for science, in-space resource utilization demonstrations and strategic partnerships sought through recent BAA

- **Our studies have determined that essentially the same flight system can support both inflatable and robotic asteroid capture options. Regardless of the capture option, the SEP spacecraft can make substantial asteroid mass available for crewed mission docking and astronaut exploration and sampling in the mid 2020's.**

Key Aspects of the ARM Vision

- **Moving large objects through interplanetary space using SEP**
- **Integrated crewed/robotic vehicle stack operations in interplanetary space-like trajectory**
  - Integrated attitude and control, e.g. solar alignment
  - Multiple hour complex EVAs
- **Opportunity for workforce to share knowledge and learn together over the next decade**
  - HSF hardware deliveries to and integration and test with robotic spacecraft
  - Handoff of robotic spacecraft operations to HSF mission operations





Asteroid Redirect Mission
Broad Agency Announcement

Selected 18 (of 108) proposals totaling $4.9M for six-month studies to define and mature system concepts and to assess the feasibility of potential commercial partnerships. Study results will inform the ARM Mission Concept Review.

Asteroid Capture Systems: *Inflatable and deployable capture systems, robotic arms, pneumatic jacks, and grippers.*

- Airborne Systems
- Space Systems/Loral
- Jacobs
- Altius Space Machines

Rendezvous Sensors: *Sensor suite for AR&D commonality across multiple mission applications*

- Ball Aerospace
- Boeing

Adapting Commercial Spacecraft for ARM:
SEP modules based on existing buses to reduce development cost

- Boeing
- ExoTerra Resource
- Lockheed Martin
- Space Systems/Loral

Partnerships for Secondary Payloads:
Leveraging external development of small spacecraft, hoppers, and kinetic impactors.

- The Planetary Society
- Planetary Resources
- Honeybee Robotics
- Applied Physics Laboratory
- Deep Space Industries

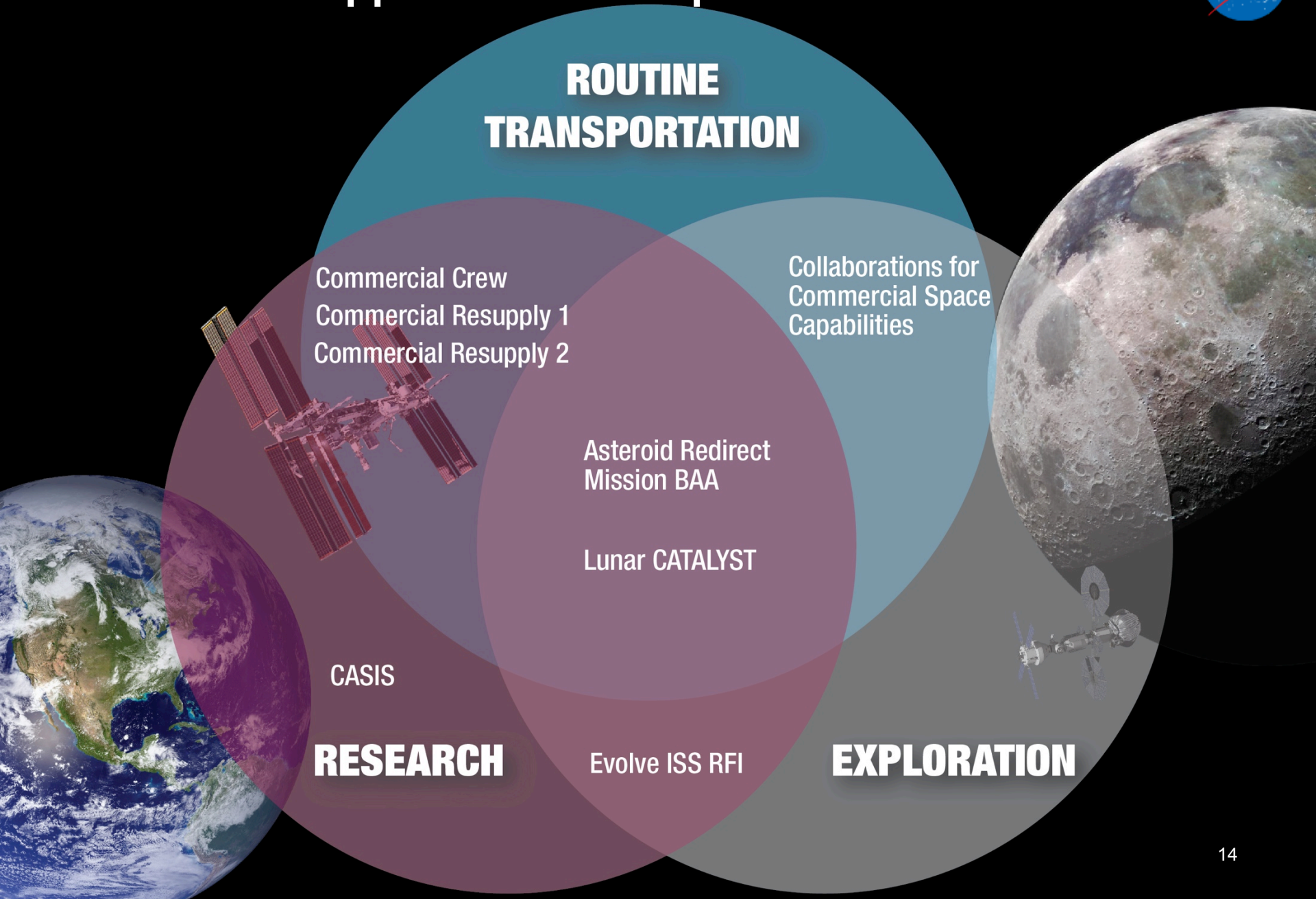
Partnerships for Enhancing the Crewed Mission: *Including commercial objectives in ARM and developing EVA tools.*

- Deep Space Industries
- Planetary Resources
- Honeybee Robotics

ARM Milestones to Mission Concept Review, February 2015

FY14 Risk Reduction Plan for Boulder Capture Concept Option	Apr 3, 2014
BAA Notice of Intent Due	Apr 4, 2014
PPBE16 program submits due	Apr 28, 2014
BAA Proposal Due Date	May 5, 2014
Initial 6-DOF Closed-loop Prox Ops Sim	June 03, 2014
STMD Solar Array Systems development Phase 1 complete	**Jun 2014**
BAA Awards	**NET Jul 14, 2014**
Option A Test Bed Operational	**July 01, 2014**
BAA Kickoff Meetings	**Week of Jul 21**
STMD SEP Solar Array RFP release	**Sep 1, 2014**
STMD Integrated Thruster performance Test with 120V PPU	**Sep 2014**
HEOMD MACES EVA end-to-end mission sim complete	**Sep 2014**
Full scale 2-D flat-floor landing testing	**October**
STMD Electric Propulsion RFP release	**Oct 12, 2014**
BAA Interim Reports	**Oct 31, 2014**
STMD SEP Solar Array RFP release	**Oct 2014**
STMD Electric Propulsion RFP release	**Nov 2014**
Robotic mission concept Option A/B downselect	**mid Dec 2014**
BAA Period of Performance Ends	**Jan 12, 2015**
Mission Concept Review	**Feb 2015**

Commercial Opportunities in Space with NASA



National Aeronautics and Space Administration

Public Engagement & Outreach

Human Exploration Strategy

Engagement Product Development: *Pioneering Space*

Pioneering Space
Update *Voyages* (2011) to incorporate Evolvable Mars Campaign study results and provides additional details in the HSF plans for the pioneering of Mars.

***Pioneering Space* development schedule:**

Dec 2013	- **Evolvable Mars Campaign** kickoff
May	- **Pioneering Space White Paper** released
June	- **EMC** study interim status #1
July	- NAC meetings
Aug	- **EMC** study interim status #2
Sept	- **EMC** FY14 outbrief
Sept	- **EMC** FY14 findings integrated into draft
Sept-Oct	- Stakeholder discussions
Fall	- NAC meetings
Dec	- Final ***Pioneering Space*** document ready for publication

Reaching for New Heights

NASA drives advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth.

Earth Right Now

Your Planet is Changing. We're on it.

Highlights NASA's role in Earth science and the value to society of Earth and climate research, leveraging 5 Earth science missions launching in 2014

NASA is studying Earth as a system with a unique vantage point from space. We share knowledge, providing a critical global view for addressing climate and societal issues.

Launched: January 2014

Our Solar System and Beyond

Our Journey of Discovery.

Share the amazing results of NASA's research and discoveries of Earth's neighborhood and the cosmos.

Place the spotlight on astrophysics, heliophysics and planetary fundamental questions and discoveries.

Campaign launch: Early calendar year 2015

ISS

We're Working Off the Earth, For the Earth.

Migrate from a communications model of 'space operations' to one of 'relevance' with a focus on research and benefits to humanity.

Convey ISS as the foundation on which our "Path to Mars" can be seen as achievable and sustainable.

Campaign Launch: May 21, 2014

Aeronautics

NASA is With You When You Fly.

Highlight benefits of NASA aeronautics current and future research and mark 100th anniversary of NACA.

Communicate benefits of decades of NASA research and NASA-developed technologies, and feature NASA's current and anticipated benefits to the flying public.

Campaign launch: November 2014

Mars

NASA's Path to Mars.

Highlight challenges and opportunities in going to Mars. Features Mars planetary research, enabling research and technologies, SLS/Orion and human exploration path to Mars.

Campaign Launch: Summer 2014

Technology

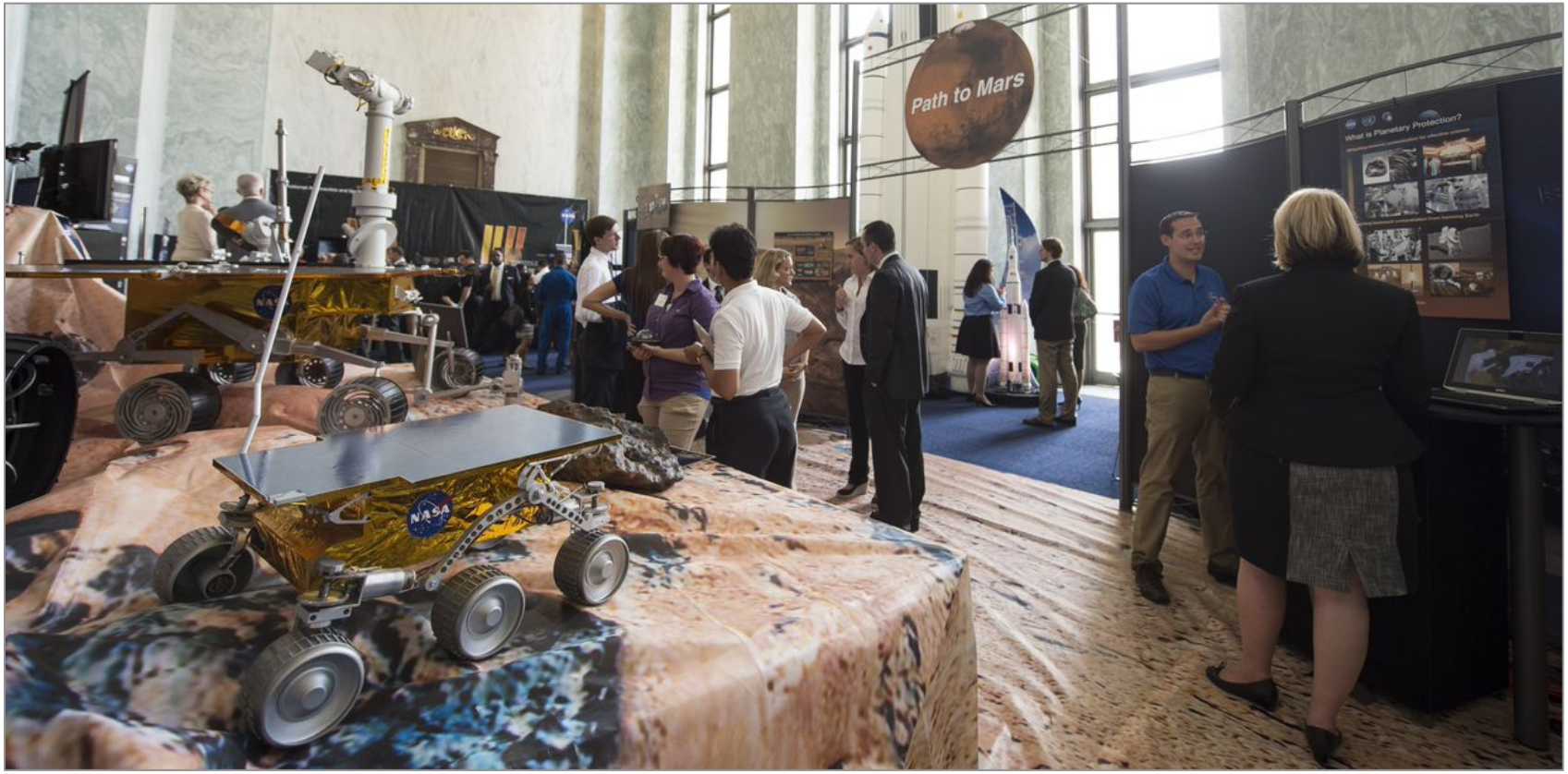
Technology Drives Exploration.

Highlights technologies across the agency and importance and value of those investments.

Feature technology demonstration events and launches, with ancillary public engagements and a robust web and social media presence.

Campaign launch: **June 2014**

Public Engagement and Outreach



- NASA frequently engages with Congress to keep our stakeholders informed about progress being made on the Agency human exploration efforts

- During recent NASA's Exploration Day On the Hill held on June 11, we were able to share our messages with approximately 500 staffers and 11 members of Congress

Public Engagement and Outreach

- We're expanding NASA's reach and engaging new audiences through the media, including social media and targeted engagement strategies (World Cup).
- Frequently issues press releases.
- Works closely with the Office of Education to collaborate with schools and universities in order to develop our next generation of STEM leaders.

"ESPN SportsCenter will air a Tuesday, June 24 in-flight interviews. ESPN.com is being used to promote the upcoming World Cup segment with NASA on Tuesday. They are aiming for 9:25 EST. and all is tracking well toward completion, aiming for 9:25am EST. Looks like it'll get some great coverage –

See the link below from ESPN for a sneak peak.

http://post.creativegroup.tv/ESP_SCNASA

Public Engagement and Outreach

- We pursue participation in venues that raise public awareness, value, and appreciation of the International Space Station and how it fits into the human to Mars
- Destination Station, a travelling exhibit, promotes research opportunities, educates communities across the Country about activities performed on the ISS, and communicates the real and potential impacts of the ISS on our everyday lives.
- NASA astronauts, scientists and staff travel to a few cities a year sharing the wonders of the ISS through general public events, researcher meetings, education activities and legislative discussions.

Public Engagement and Outreach – EFT-1

INTERNAL COMMUNICATION

A broad range of products and activities are used to communicate information on Orion and progress to employees, news media, stakeholders and the public:

- Program updates via “All-Hands” meetings
- Speakers across the agency
- Newsletters and memos
- Supplier and subcontractor visits
- Social Media
- Web stories
- Space Flight Awareness events
- Recognition awards and events (Program Managers)
- Banners, posters and signage

Public Engagement and Outreach

EXTERNAL COMMUNICATION

Education outreach is planned in conjunction with technical meetings, supplier visits, special events and major NASA and Orion milestones:

- Web stories, information, education materials and images posted to nasa.gov
- Outreach and engagement through social media channels
- School and University outreach (presentations to students, summer camps, and NASA/NIA/Lockheed Martin Exploration Design Challenge)
- Space and Science Museums (Space Days, NASA Visitor Center events) NASA exhibits at major events
- Media Briefings, Press releases, interview opportunities
  - State and local representatives are notified when events occur in their city/state
- Collateral materials, videos, graphics
- Grassroots efforts (“I’m on Board” banner, Spot Orion campaign)
- Use of existing NASA partnerships (Lego, Mattel, Sesame Street)

Future Plans

- HEOMD will continue to work closely with internal organizations (OLIA, OComm, OE, Mission Directorates and Field Centers) as well external organizations to increase awareness and understanding and grow support for NASA's future Exploration plans.
- HEOMD will continue to education the NASA workforce in order to create a cadre of Ambassadors that effectively share NASA's exploration plans with the public.

HUMAN EXPLORATION

NASA's Path to Mars

EARTH RELIANT

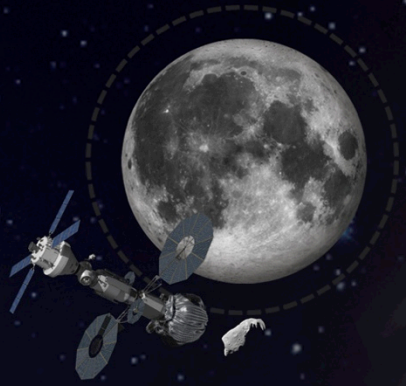
MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS

Mastering fundamentals aboard the International Space Station

U.S. companies provide access to low-Earth orbit

PROVING GROUND

MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS

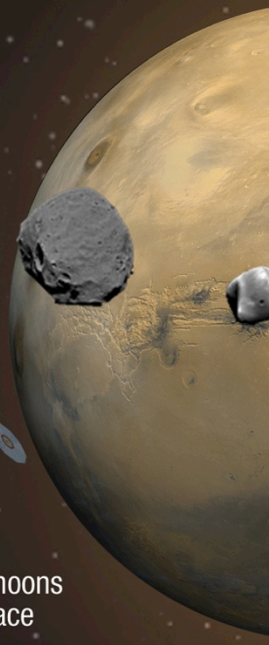


Expanding capabilities by visiting an asteroid redirected to a lunar distant retrograde orbit

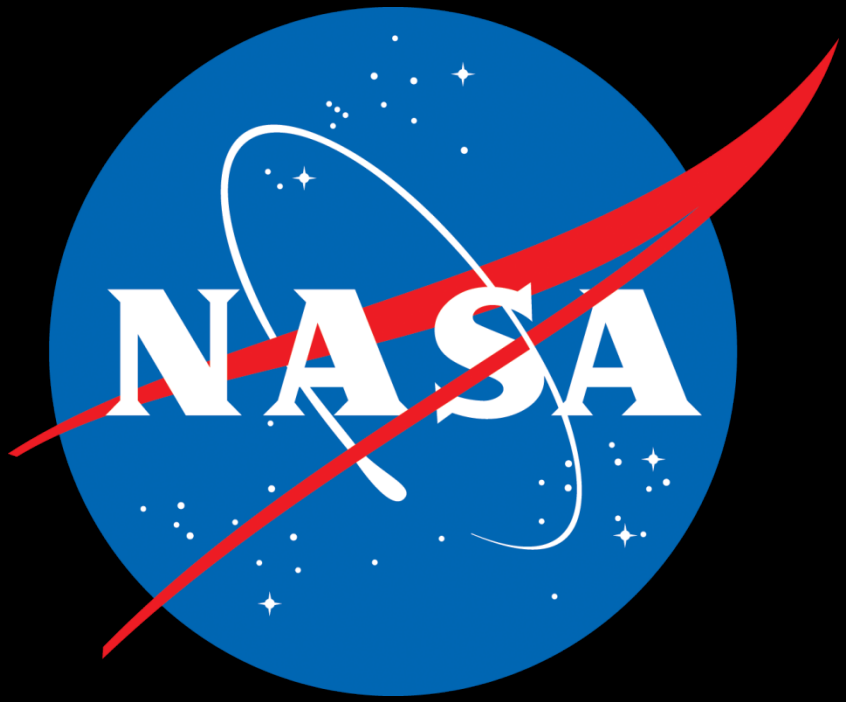
Traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft

MARS READY

MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS



Exploring Mars, its moons and other deep space destinations


NASA